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Fan effects in event-based prospective memory

Gabriel I. Cook
Claremont McKenna College, Claremont, CA, USA

Richard L. Marsh
University of Georgia, Athens, GA, USA

Jason L. Hicks and Benjamin A. Martin
Louisiana State University, Baton Rouge, LA, USA

Three experiments investigated whether event-based prospective memory was affected by the associative fan of the cues to be detected. The associative fan was operationally defined as the number of associates paired with event-based cues in a paired associate learning phase. Subsequent to the paired associate learning, participants were given a lexical decision task in which event-based cues were embedded. The results from Experiments 1 and 2 confirmed that a larger associative fan significantly reduced event-based cue detection. The third experiment confirmed that the absolute strength of an association does not affect performance, rather the number of associations does. As an ancillary issue, the authors tested whether cue detection was affected by the familiarity of the background words used in the lexical decision task. No consistent evidence for a discrepancy plus search model of prospective memory was found.

Cues in our environment remind us of past experiences, with certain cues being more or less effective at doing so. For example, noticing a statue on a shelf may evoke a memory of a birthday party at which it was received as a gift. However, the human memory system does not exist simply to record events in our personal past or to store faithfully the skills that we need to subsist in our everyday lives. Indeed, it stores personal thoughts, records of imagination, dreams, and internal feelings that are not necessarily accessible to an outside observer of our lives. Among those thoughts that are recorded are a class of plans or desires that we have for our own future behaviour, and these can be labelled collectively as intentions. Unlike episodic and semantic memory, which have been studied systematically for over a century, memory for intentions was an overlooked area, probably because psychologists struggled to develop laboratory-based analogues of real-world intentions. Fortunately, the field has successfully made it past that hurdle, and now solid and exciting research on prospective memory (as it has been labelled) is being produced at a very steady (and perhaps increasing) rate. This article examines a facet of event-based prospective memory that has hitherto gone uninvestigated—whether cue detection is affected by the number of pre-existing associations to that cue.

In the typical event-based prospective memory task, participants are engaged in an ongoing activity that is intended to simulate some of the demands of everyday life. Some of the tasks that have been used include: rating the sensibility of sentences; rating words on various dimensions;

Address correspondence to: Richard L. Marsh, Department of Psychology, University of Georgia, Athens, GA 30602-3013, USA. E-mail: rlmarsh@uga.edu

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tests of short-term memory; naming famous faces; making lexical decisions, and so forth (e.g., Marsh, Hicks, & Cook, 2005; Maylor, 1998; McDaniel, Guynn, Einstein, & Breneiser, 2004; McGann, Ellis, & Milne, 2003; West, Krompinger, & Bowry, 2005). Participants are given an intention to make an overt response when an event-based cue is encountered, such as when a face with glasses appears or when a word is encountered that denotes a fruit. Much has been learned over the years about the interaction between the characteristics of the cue and the nature of the ongoing task that causes a cue to be detected versus overlooked. For example, cue words that are distinctive against background words increase prospective performance, as will cue words that are less familiar (McDaniel & Einstein, 1993). In addition, more specific cues (e.g., *tiger*; a focal cue) elicit better performance than do more general cues (e.g., *animal*; a nonfocal cue; Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995). Ongoing tasks that highlight the features of the cue, such as making judgements about whether or not words have double letters when holding an intention to respond to palindromes, will also improve event-based performance (Marsh, Hicks, & Hancock, 2000; Maylor, Darby, Logie, Della Sala, & Smith, 2002).

One aspect of event-based cues that has not been investigated directly concerns their associative fan. This gap in the literature is rather surprising, given that one theoretical explanation for cue detection depends, in part, on the probabilistic operation of a reflexive association between the cue and the target action (e.g., Einstein et al., 2005; McDaniel & Einstein, 2000; McDaniel et al., 2004). In this multiprocess view of event-based prospective memory, the interaction of the cue and the cognitive processing required for the ongoing activity jointly determine how much resources will be needed for cue detection. More importantly, this theory also posits that a strong association between the cue and the target action increases the probability of cue detection. However, as with other sorts of memory tasks, the association between the cue and the target action is likely to be mediated by other associations from the cue to other concepts in memory. The multiprocess view was based in part on earlier theoretical mechanisms where a cue would evoke some familiarity through an automatic association that would then prompt a more strategic search for what the cue signified (e.g., Einstein & McDaniel, 1996; Guynn, McDaniel, & Einstein, 2001). Both the initial familiarity (or its discrepancy from the background as specified by McDaniel et al., 2004) and the probability of a successful search may depend on the associative fan of the cue to be detected (cf. a spreading activation account by Ellis & Milne, 1996). In its simplest terms, an event-based cue that only has associations to a few other concepts in memory may have a higher probability of being detected than a comparable cue with greater numbers of associations to other concepts. Thus, this prediction is derived directly from standard fan effects in memory (Anderson & Bower, 1973).

In the memory literature, two basic types of fan effects are obtained. The standard, and more common, report is that the higher the associative fan, the slower and more error prone the episodic retrieval. In these sorts of studies participants learn facts such as *The lawyer is in the park*. The more associations that are added to the learning set related either to the subject (*lawyer*) or to predicate (*park*) terms, the more both reaction times and error rates increase. Outcomes such as these are usually explained by spreading activation theories in so far as there will be less activation reaching each concept from the particular node originally activated. Fan effects are generally obtained any time episodic memory is queried, and these findings are generally quite robust. By contrast, reverse fan effects occur when semantic memory, rather than episodic memory, is queried. For example, in a category exemplar verification task (e.g., is a cucumber a vegetable?), the higher the associative fan, the faster the reaction time and the smaller the error rate. In such tasks the higher (or denser) connectivity of related concepts feeds activation back onto the queried item thereby enhancing performance as compared with a lower (or sparser) set of associated items (Kroll & Klimesch, 1992). Clearly, event-based prospective memory in the real world is closer to an episodic memory task (e.g., ask my secretary to type an envelope when I see her next); and consequently, the literature predicts that the greater the number of associations from an event-based cue, the lower the probability that the intention comes to mind.

According to the multiprocess view, cue detection is determined by a cue's salience against its background, whether the ongoing task focuses attention on the relevant features of the cue, and the strength of the association between the cue and the target action.[1] Based on the last item in this list, we believe that the associative fan from the event-based cue will also affect detection and subsequent prospective memory performance. To take an everyday example, a given cue in our environment can be associated with a multitude of intentions. One's refrigerator may remind one that a meal needs to be prepared soon, or additionally that a trip to the supermarket had been planned, or even that one has the intention to call the repair company to fix the ice machine. Seeing one's car could remind one that it is low on fuel, that it needs to be washed, that it requires a tune-up, or even that a recall notice went unheeded. These two examples use intentions as the associative fan, but we do not mean to imply that only intentions increase the associative fan from an event-based cue. Seeing one's car may remind us that we almost had an accident a week ago, that we received a ticket for failing to wear a seat belt, or that a friend borrowed it. Our point is that the associative fan for various cues varies in the real world, and we believe that the fan is likely to affect the probability of any particular one of those concepts or intentions coming to mind. That is, an event-based cue (*dog*) might activate the target paired with it (*chalk*) rather than a previously established intention.

There is one study in the literature that may be conceptually consistent with the foregoing analysis. McDaniel and Einstein (1993) attempted to manipulate the familiarity versus distinctiveness of event-based cues. They chose as familiar cues ones that were of high word frequency (e.g., belt, post, fuse, movie), and as distinctive cues ones that were quite rare (e.g., monad, bole, sone, yolif). They found generally better prospective memory for the rare words, and also that distinctiveness of the word from its background increased performance (i.e., rare words against a background of familiar words and vice versa). They claimed that highly familiar cues might have more associations and thereby actually decrease event-based prospective memory, much as we have argued thus far. However, subsequent to their report, Nelson and McEvoy (2000) have convincingly demonstrated that low- versus high-frequency words do not differ in the number of associations that they have to other concepts in memory. Thus, McDaniel and Einstein's (1993) results must be owing to some other factor, such as familiarity, but they are probably not a result of the pre-existing fan as they suggested. So their results beg the question of whether event-based cues vary in effectiveness as a consequence of the associative fan; and this is the question we address in this study.

The outcomes of this study are by no means necessarily preordained to demonstrate that larger associative fans necessarily decrease prospective memory performance. One viable alternative prediction is that a strong association to another concept may obscure or overshadow the association between a cue and an intention; and in this case, a smaller fan may result in worse performance than a larger fan of weaker associates. For example, it might be habitual upon seeing one's pet to check its water bowl and, consequently, forget the association to make an appointment for its annual veterinary visit. This alternative prediction is derived directly from the multiprocess view in which a strong association between a cue and the target action causes the intention to be reflexively delivered to consciousness (Einstein et al., 2005). In the same way, a strong association between the event-based cue and another concept in memory (other than the intention) may decrease the probability of the intention being drawn into consciousness. Thus, there are alternative empirical and theoretical predictions, and given the centrality of reflexive associations in the multiprocess view of event-based prospective memory, we conducted the following three experiments to explore these issues.

EXPERIMENT 1

We designed this first experiment to ascertain whether the associative fan from an event-based cue would affect its detection in an ongoing task. We operationalised the size of the fan through a pre-processing phase in which participants were asked to learn word pairs for a later cued recall test.[2] One event-based cue was associated with

[1] Einstein and McDaniel (2005) have argued that these three features surrounding a prospective memory task can determine whether a cue is focal versus nonfocal. For clarity, we continue to list separately these aspects of event-based prospective memory rather than use the umbrella terms focal versus nonfocal.

[2] We understand how the reader might be confused between the term *cue* referring to an event-based cue versus the first term of a cue–target paired associate. Consequently, we have been very careful to specify which meaning is intended, and we apologise in advance for some redundancy that is needed to avoid confusion.

one neutral word and presented eight times during the study sequence (e.g., *dog – chalk*) thereby giving it an experimental fan of one. Another cue was associated with four different neutral words, each of which was studied twice for a total exposure of eight trials. Thus, that event-based cue had an experimental fan of four, as defined here. A third event-based cue was not studied, thereby giving this control item an experimental fan of zero. On the one hand, if a larger fan activates its associates more weakly, then the association to perform the prospective memory task should also be more weakly activated and decrease the probability that the intention comes to mind. On the other hand, studying a pair like *dog – chalk* eight times may cause only the association between the words to come to mind quite strongly and decrease the probability of the intention also coming to mind.

In all three experiments we embedded each event-based cue twice in an ongoing lexical decision task that followed the pre-processing phase. For generality, the other words in the lexical decision task were either brand new words not experienced during the study phase or they were drawn from the cues and targets studied earlier. McDaniel et al. (2004) found that when the words in the ongoing task had been studied previously, the event-based cues were not experienced as discrepant from the background context, and this tended to reduce event-based performance. However, they did not find this effect consistently, and we decided to explore this issue in the context of the current study, although we admit that this issue is ancillary to our main question of interest concerning the associative fan.

Method

Participants. Undergraduate students from the University of Georgia volunteered in exchange for partial credit towards a research appreciation requirement. Each participant was tested individually in sessions that lasted approximately 30 minutes. A total of 77 participants were randomly assigned to one of two between-subjects conditions which differed as a function of whether the words in the lexical decision task were familiar (i.e., studied previously in the pre-processing phase) versus unfamiliar. The unfamiliar condition comprised 38 volunteers whereas the familiar condition comprised 39.

Materials and procedure. The pre-processing phase consisted of 160 study trials with a word pair appearing on each. A total of 20 unique cue words were paired with various numbers of target words to create cues with different fans. The three prospective memory cues were *horse*, *cow*, and *dog*. For a given participant, one of these was randomly chosen to have a fan of zero, one, or four. With a fan of zero, the cue did not appear in the study phase. With a fan of one, the prospective memory cue word was randomly paired with one particular other word as the target word (e.g., *dog – chalk*) and the pair was inserted randomly eight times into the study sequence. With a fan of four, four words were randomly chosen as targets for one prospective memory cue word and each of the four cue–target pairs was randomly inserted twice into the study sequence. Thus, the prospective memory items comprised 16 study trials in total. To ensure other nonprospective memory items had a fan of one and four, these 16 study trials were entirely replicated twice but using nonprospective memory cues (e.g., *dice*) as the cue in the cue–target word pairs (for an additional 32 study trials). The remaining 112 study trials were used mainly to disguise the nature of the study phase and avoid the animal words becoming salient. Seven randomly chosen cue words were paired with eight new target words every time they were seen (an additional 56 trials) thereby giving them a very large fan of eight. Finally, seven randomly chosen cue words were paired with two new target words, and each was inserted four times into the study phase giving them a fan of two, thereby adding the final 56 trials to the pre-processing study phase. As mentioned previously, these procedures resulted in a total of 20 unique cue words appearing repeatedly in cue–target pairs throughout the 160 trial study phase.

Following the study phase, a lexical decision task was administered. The parameters of the ongoing lexical decision task were identical to those used by Marsh, Hicks, and Watson (2002). There were 180 trials, with equal numbers of valid English words and pronounceable nonwords. The 80 valid words were chosen either from the target words experienced during the study phase or from a list of new words that was roughly equated to the studied words on both word length and normative frequency of occurrence. A fixation point and warning tone preceded each letter string; and the participant's word–nonword response (using the F and J keys) cleared the monitor and the message *waiting* appeared. Participants had been instructed to press the space bar to initiate the next trial, which caused the next fixation point to appear. Prospective memory cues occurred every 25 trials during the lexical decision task beginning on trial 25 through trial 150 (for a total of 6 prospective memory trials). The cues were presented randomly under the constraint that all three cues had to be experienced once before their repetition occurred.

At the outset of the experiment, participants were instructed that they would be learning a series of word pairs for a later cued recall test. They were correctly informed that they should try and learn the cue–target pair so that they could recall the target when the cue was given back to them during a test of their memory. A 250-ms warning tone preceded each pair to maintain the participant's attention during the learning phase. Following the warning tone, each word pair was studied in the centre of the computer monitor for 2 seconds. All instructions in all phases of the experiment were first read from the computer monitor and then reiterated by the experimenter in his or her own words. Following the study phase, instructions for the lexical decision task were delivered. At the tail end of these instructions, the experimenter explained that we were also interested in their ability to remember to perform tasks in the future. All participants were given the intention to respond to words denoting animals by pressing the /-key during the waiting message that followed making their word response. They were given the example *monkey*, which never appeared during the lexical decision task. Once the participant understood these instructions, the experimenter cleared the computer monitor and asked participants to work on a maze distractor task for 4 minutes as timed with a hand-held stopwatch. After the distractor task, the participants commenced the lexical decision task without any reminder about the animal intention.

At the conclusion of the lexical decision task, instructions were given for the cued recall task. Each of the 20 unique words was presented in the centre of the computer monitor and participants were asked to type in one of the target words that was paired with it. The computer scored recall using an algorithm meant to minimise the influence of typing mistakes. Items with a fan of one had only one correct response, whereas items with a fan of two to eight had multiple correct responses. So in this regard the cued-recall test was not standard, but the results from this phase were only intended to convince the reader that we obtained standard fan effects in cued recall as described by Anderson and Bower (1973).

Results and discussion

Unless specified with a p value in this experiment and those that follow, the probability of a Type I error does not exceed 5%.

Lexical decision task. Although ancillary to our main motivation for conducting this study, latencies on trials exceeding 2.5 standard deviations from a participant's mean of a given trial type were trimmed, and trials on which errors were made were also removed. These procedures resulted in acceptable data loss of 3.8%. The familiarity of the background manipulation did not affect the speed at which participants performed the lexical decision task because the average latencies to words were 740 ms and 720 ms in the unfamiliar and familiar conditions, respectively, $t(75) < 1$, ns.

Prospective memory. Event-based prospective memory is summarised in Table 1 as the propor-

TABLE 1
Event-based prospective memory performance (proportions) as a function of condition and type of item, Experiments 1 and 2

Experiment and condition	*Prior exposure of the prospective memory cue*			
	New (Fan 0)	*Strong (Fan 1)*	*Weak (Fan 4)*	*Average*
Experiment 1				
Unfamiliar	.86	.88	.70	.81
Familiar	.72	.65	.70	.69
Experiment 2				
Unfamiliar	.71	.77	.63	.70
Familiar	.63	.69	.53	.61

tion of cues detected. Late responses to event-based cues were rare, and they were not counted as correct. We conducted a 3 (fan: 0, 1, 4) $\times$ 2 (unfamiliar vs. familiar background words) mixed-model Analysis of Variance (ANOVA), which yielded a significant interaction between fan size and familiarity of the background words in the task, $F(2,\ 150) = 4.10$, $MSE = 0.059$, $\eta_p^2 = .05$. There was also a main effect of fan, $F(2,\ 150) = 3.07$, $\eta_p^2 = .04$, and a marginally significant main effect of familiarity, $F(1,\ 75) = 3.49$, $MSE = 0.252$, $p = .06$, $\eta_p^2 = .04$. When the background context was unfamiliar, a larger fan from the event-based cue reduced prospective memory performance. Performance on the cue with a fan of four is statistically lower than a fan of either zero or one, smaller of the two $t(37)$s = 2.51. As the row marginal mean demonstrates, encountering the same cues against a background of familiar items modestly reduced overall cue detection, causing the effect of fan to be non-significant, all $t(38)$s $<$ 1.15. That outcome is consistent with McDaniel et al.'s (2004) argument that discrepancy of a cue from its background can affect cue detection.

Cued recall. Cued recall performance is summarised in Table 2 as the proportion of each type of trial that elicited a correct response. The point of reporting these data is to demonstrate that larger fans reduced cued recall. Within each type of the three basic types of word pairs, we defined one fan as small and the other as large, thereby allowing us to submit the data to a 2 (fan) $\times$ 3 (type of word pair) $\times$ 2 (familiarity of the background) ANOVA. Cued recall was more successful when concepts had a smaller fan, $F(1,\ 75) = 14.48$, $MSE = 0.131$, $\eta_p^2 = .16$. That outcome is consistent with the fan effect in memory (Anderson & Bower, 1973) despite cues with larger fans having more potentially correct targets to be recalled. No other term in the ANOVA model resembled a significance level that remotely approached standard conventions.

EXPERIMENT 2

The results of Experiment 1 suggest that event-based cues with a larger fan, under some circumstances, can lead to a reduction in event-based prospective memory. That same experiment also demonstrated that the fan effect might not be present when performance is otherwise compromised, in that case by increased familiarity of the background context. However, Experiment 1 only tested the case of a forward association from a prospective memory cue to target items. We had suggested that one alternative outcome could be that the prospective cue elicited the target associate rather than the intention. Obviously this did not happen, but it does suggest that we test learning the event-based cues as targets in the cue–target pair. If participants are making forward associations from the cue to the target members of the pairs, perhaps the backward association will not be as influential on event-based performance. By reversing the cue–target relationship for the animal items, one could predict that the backward fan to the studied cue(s) of the pair may not influence event-based detection. Much of this will depend on whether the associations that people are making are symmetric such that forward and backward recall probabilities are the same. This issue has been debated over the years with some claiming asymmetry (e.g., Anderson & Bower, 1973) and

TABLE 2
Cued recall performance (proportions) in Experiments 1 and 2 as a function of type of studied item

Experiment and Condition	*Type of word pair seen at encoding:* *Prospective cues* Strong (Fan 1)	*Prospective cues* Weak (Fan 4)	*Non-prospective cues* Strong (Fan 1)	*Non-prospective cues* Weak (Fan 4)	*Other word pairs* Strong (Fan 2)	*Other word pairs* Weak (Fan 8)
Experiment 1						
Unfamiliar	.71	.53	.62	.53	.65	.48
Familiar	.54	.51	.63	.55	.69	.47
Experiment 2						
Unfamiliar	.71	N/A	.66	.51	.59	.51
Familiar	.74	N/A	.64	.60	.68	.48

N/A indicates data not available due to a programming error.

others claiming that symmetry predominates (Ekstrand, 1966; Rizzuto & Kahana, 2001). If the reduction in event-based performance is due to an absolute fan, and recent claims of symmetry better characterise the state of affairs regarding forward and backward associations (e.g., Rizzuto & Kahana, 2001), then reversing the cue–target relationship for the animal items will not affect the outcome found in Experiment 1; and consequently, this experiment will provide a much welcomed replication of the deleterious impact of increasing fan on event-based performance.

Method

Participants. Undergraduates from the University of Georgia volunteered in exchange for partial credit towards a research appreciation requirement. Each participant was tested individually in sessions that lasted approximately 30 minutes. A total of 70 participants were tested with half being tested in each of the familiar and unfamiliar conditions, as defined in Experiment 1.

Materials and procedure. The materials and procedure for this experiment were identical to the previous one in all respects except two. First, the cue–target relationship for animal items was reversed during the pre-processing phase such that if *cow–garage* were studied in Experiment 1, then participants studied the associates in the reverse order in this experiment. As in the first experiment, all of the randomisation procedures were executed anew with each participant tested, and no pair was constant across participants. Second, a software programming error occurred which caused the fan of four animal items (i.e., weak pairs) to be incorrectly scored during the final cued recall task. Consequently, those data are missing from this experiment. Given that these data are used merely to confirm that standard fan effects are obtained, we believe that the remaining data, which was scored correctly, should be sufficient to do so.

Results and discussion

Lexical decision task and prospective memory. As in Experiment 1, the familiarity manipulation did not appear to affect the way the two groups approached the lexical decision task because the average latencies in the unfamiliar and familiar conditions were 717 ms and 711 ms, respectively, $t(68) < 1$, *ns*. Event-based cue detection is presented in the lower half of Table 2. We conducted the 3 (fan) $\times$ 2 (familiarity of background) ANOVA and found only a main effect of associative fan, $F(2,\ 136) = 8.81$, $MSE = 0.046$, $\eta_p^2 = .12$. Replicating Experiment 1, an increased fan of four items depressed cue detection as compared with a smaller fan of zero or one item encountered during study, smaller of the two $t(69)\text{s} = 2.41$, pooling over the familiarity conditions. Like Experiment 1 there was a nominal decrease in event-based cue detection when the background words were familiar, but the effect was not statistically significant, $F(1,\ 68) = 1.06$, *ns*. Why the familiarity manipulation failed to replicate Experiment 1 is unclear. However, McDaniel et al. (2004) had difficulty replicating this effect, and it was not statistically significant in Experiment 3 of that earlier report. Perhaps only half of the stimuli being familiar weakens the effect because all of the nonwords in the lexical decision task are unfamiliar. To investigate this effect a bit further, we pooled over this experiment and the previous one (acknowledging the dangers in doing so); and we found that the familiarity of the background words does reduce event-based cue detection, $F(1,\ 145) = 3.88$, $MSE = 0.326$, $\eta_p^2 = .03$. Given the amount of power needed to detect the effect, we conclude that familiarity of the background may be a small and variable contribution to event-based cue detection. Perhaps future discussions of this contribution should figure less prominently in the multiprocess view.

Cued recall. The data from the cued recall phase of this experiment are summarised at the bottom of Table 2. We analysed the data from the control and other trial types using a 2 (fan as small or large) $\times$ 2 (type of word pair) $\times$ 2 (familiarity of the background) mixed-model ANOVA, and only associative fan was statistically significant, $F(1, 68) = 12.96$, $MSE = 0.068$, $\eta_p^2 = .16$. No other terms in the model approached conventional levels of significance. Therefore, these data corroborate that a fan effect was obtained in the final cued recall test, just as occurred in Experiment 1.

EXPERIMENT 3

The previous two experiments have confirmed that a larger associative fan can detrimentally impact event-based cue detection. In neither experiment was there a difference between a fan of zero and one. Rather, detection suffered under a fan of four relative to the two other types of event-based cues. In order to definitively rule out that the strength of association does not matter, we conducted this last experiment. The alternative hypothesis for these experiments was that a strong memory that competes with the intention might interfere with cue detection. Perhaps the eight presentations in Experiments 1 and 2 were not sufficient to elicit that kind of competition. Consequently, we parametrically manipulated the number of times an animal and an unrelated target word were studied during the pre-processing stage of this experiment. If a strong associate can compete with an intention, then we predicted that 15 study trials should be sufficient to observe that effect (i.e., nearly doubled the study trials of the strong cues in the previous experiments).

Method

Participants. A total of 85 University of Georgia undergraduates volunteered in exchange for partial credit towards a research appreciation requirement. Each participant was tested individually in sessions that lasted approximately 30 minutes. A total of 45 participants were tested in the unfamiliar condition, and the remaining participants were tested in the familiar condition.

Procedure. The experiment was virtually identical to Experiment 1 except in the following ways. In the previous experiments, a total of 16 study trials exposed two event-based cues during learning. We divided those study trials plus half of the nonprospective memory control trials (another 16 study trials) into a strengthening manipulation. That manipulation was for one event-based cue to be studied once as the cue in the cue–target word pair, another event-based cue to be studied 5 times, a third event-based cue to be studied 11 times, and a final cue to be studied 15 times. Thus we also increased the number of event-based animal cues studied from two to four during the study phase. Although each occurrence of a cue–target pair was consistent for each prospective memory cue for a given participant, the target items were randomly chosen anew by the software for each participant. Which of the cues was assigned to the level of strengthening was randomly determined by the software used to conduct the experiment. In the lexical decision test phase, event-based cues were initially presented on trials 18, 38, 58, and 78, and were then repeated in a different random order on trials 98, 118, 138, and 158. In all other respects, this experiment was identical to Experiment 1.

Results and discussion

Lexical decision and prospective memory. The average latencies in the unfamiliar and familiar conditions were 710 ms and 695 ms, respectively, $t(83) < 1$, *ns*. For brevity, we narrowed our focus of attention to event-based cue detection and cued recall for the animal items only. We assessed a 4 (1, 5, 11, or 15 study trials) $\times$ 2 (background familiarity) mixed-model ANOVA on the proportion of cues detected as summarised in the top half of Table 3. The strengthening manipulation and its interaction with condition were not statistically significant, $F(3, 249) < 1$, *ns*. The main effect of strengthening was also not significant, $F(1, 83) < 1$. Moreover, the familiarity of the background words also failed to produce a difference in cue detection, $F(1, 83) < 1$, *ns*. Therefore, we believe that we have definitively eliminated the possibility that a strong association

TABLE 3
Event-based prospective memory and cued recall performance as a function of number of times items strengthened at encoding

Measure and condition	Number of times strengthened at encoding: One	Five	Eleven	Fifteen	Average
Prospective memory					
Unfamiliar	.75	.76	.76	.76	.76
Familiar	.75	.78	.71	.78	.75
Cued recall					
Unfamiliar	.06	.40	.64	.62	.43
Familiar	.05	.40	.61	.65	.40

to another, single concept influences event-based cue detection. In addition, the effect of background familiarity produced a tiny 1% difference in the correct direction, and consequently, that effect has proven itself to be unreliable in the current paradigm.

Cued recall. Cued recall performance can be found in the lower half of Table 3. We conducted a 4 (1, 5, 11, or 15 study trials) $\times 2$ (background familiarity) mixed-model ANOVA on the final cued recall task. Progressively strengthening the relationship between the cue and target had the predictable effect of increasing cued recall $F(3,\ 255) = 37.69,\ MSE = 0.053,\ \eta_p^2 = .31$. Thus, although the strengthening increased retrospective memory, it had no effect on prospective memory.

General discussion

The empirical results from this study are straightforward: a standard fan effect reduced event-based detection; the absolute strength of an association did not affect detection; and the familiarity of the background context had an inconsistent effect on detection. Given that we used a categorical intention in this experiment, one way to conceive of the cognitive processing taking place is that each cue has a backward association to its category (in this case it was animals). In order to make the prospective response, participants must categorise the cue *horse* as an animal, which should activate the intention. If the cue has many other associations, the spread of activation backward to the category of animal will be reduced because other concepts in memory are being simultaneously activated (Anderson & Reder, 1999). Evidently, the absolute strength of an association to another concept matters less to event-based cue detection than does the fact that episodic associations were formed during the course of the pre-processing phase of the experiment. Although we have not tested this, we presume that words with smaller pre-experimental associative fans would serve as better event-based cues than those with larger pre-experimental fans. We do not know how large the difference in pre-experimental fan must be to find a significant effect on event-based cue detection. However, if pre-experimental fans operate similarly to the definition of fan in the current study, then a difference of three additional concepts is sufficient to affect cue detection.

Several findings in the prospective memory literature converge on the idea that event-based performance depends, in part, on the spread of activation among concepts. Ellis and Milne (1996) found that category cues like the ones used in this study elicited better performance when they were high output dominance exemplars (i.e., at the top of the list in the Battig & Montague, 1969, norms). They argued that at intention formation people sample memory from the category briefly, and items that are highly typical receive some activation that later boosts their detection in the ongoing activity. Nowinski and Dismukes (2005) also argue that event-based cue detection is sensitive to spreading activation. In their study, participants formed the intention to respond to fruit words while learning about one of two ongoing activities that were subsequently interleaved with one another. Nowinski and Dismukes labelled this the associated activity. After performing a block of trials with that associated ongoing activity, participants learned what the other ongoing task was and how to perform it. In subsequent blocks of the ongoing task, cue detection was better in the ongoing task associated with intention formation. Nowinski and Dismukes argued that upon entering the context that had an association to the intention, some activation accrued to the intention, thereby causing higher cue detection.

Mäntylä (1993) also argued that associative priming mechanisms were operative in event-based cue detection. He engaged some participants in a category fluency task requiring them to list members of certain categories. When primed in this way, he found that event-based cues from those categories (as compared with different categories) were better detected under certain circumstances. He argued that items received activation from the fluency task, which later facilitated their detection. These activation-based accounts are consistent with the finding that materials associated with an intention appear to reside in memory at a higher baseline level of activation, or at least can be revived from memory more quickly (e.g., Goschke & Kuhl, 1993; Marsh, Hicks, & Bink, 1998). In that work, participants learn small scripts for activities like brewing coffee or setting a table. If they are asked to perform one of those later, then faster latencies (in either a recognition memory or lexical decision task) are found to items from the to-be-performed script as compared with another script that lacked any intentionality.

The associative activation effects summarised here are likely to operate with many intentions, but we are by no means saying they constitute the rule. The other half of the multiprocess view specifies that some intentions require strategic search and cognitive control for successful completion. For example, certain prospective memories may require detecting cues that are nonfocal (e.g., Einstein et al., 2005) or that are in the periphery of attention (Hicks, Cook, & Marsh, 2005). A laboratory-based example of such intentions is finding the letter string *tor* in the word *dormitory*, whereas everyday examples might include remembering to buy postage stamps at the supermarket (a focal task at the Post Office) or asking the carwash attendant if she has any Sacagawea dollar coins (a focal task at a bank). In these cases, how associative mechanisms can facilitate prospective memory is unclear, and in the everyday examples may actually decrease responding due to competing associations similar to the fan effect found in Experiments 1 and 2.

Unfortunately, we did not secure much evidence for a discrepancy plus search account of prospective memory. According to this account, cues are noticed because they are more discrepant from the background as a consequence of the extra activation they have received from priming or their direct presentation during intention formation. We were at first tantalised by the results of Experiment 1 where the fan effect disappeared under compromised performance from increasing the background familiarity of items in the ongoing task. However, we failed to replicate the effect in either Experiments 2 or 3. We have acknowledged that the nonwords were unfamiliar, and so perhaps this was not the optimal context to examine the discrepancy plus search account. However, based on the data from all three experiments, the discrepancy plus search account, rather than being a major contributor to event-based performance (McDaniel et al., 2004), may actually have only a small, variable, and relatively inconsequential role in cue detection. We come to this conclusion reluctantly, but our confidence in it is bolstered by the fact that we have looked for this background context effect on several other occasions by pre-processing words for an ongoing word-rating task and have never found the reduction in performance that should come from highly familiar background items.

Another issue that we have about the discrepancy plus search view concerns a set of alternative predictions that we could have made about performance in this study, but have chosen not to until this point in the article. Technically, based on discrepancy, we could have predicted that cues with a fan of one or four should have been detected more often than cues with a fan of zero because of their frequent occurrence in the pre-processing phase. Each cue occurred eight times in that task, making them very strong in memory, especially against a background of brand new items in the lexical decision task. Thus, a discrepancy account would perforce predict that recently experienced cues would have more familiarity than cues not experienced in the experiment. However, cues with a fan of zero were detected at rates similar to cues with a fan of one, which contradicts the straightforward predictions based on a discrepancy mechanism. Perhaps the effect is only found when specific cues are used rather than a categorical intention, but if so, then this is not a very general contribution to event-based prospective memory. Until this issue is tested directly in future research, we remain sceptical as to whether the background familiarity effect will stand the test of time.

We conclude with some practical and theoretical ramifications of the present results. From a practical standpoint, the fan effects obtained on cue detection suggest that unique cues will serve as better triggers for remembering intentions than objects that have been used in the past to elicit prospective memories. For example, one of the current authors will often place a blank index card in his breast pocket to remember to complete an intention upon arriving home from the office. Because the same cue is used repeatedly, that cue will become increasingly ineffective due to the standard retrospective memory principle of cue overload. By the same token, objects and people that have many associations attached to them should serve as poorer retrieval cues for intentions than ones that have fewer associations. From a theoretical standpoint the multiprocess view argues that strong associations between the cue and target action promote more reliable cue detection. Although we believe that this is true, the current results suggest that a larger associative fan on the cue may vitiate the effectiveness of such a cue. Although we have not tested it, we believe it would be interesting to assess which of the two effects (strong association vs. increased fan) is more influential on event-based cue detection. More generally, we listed several factors in the introduction of this paper that tend to increase event-based performance, and we believe that assessing whether the fan effect does or does not affect their benefit to cue detection could represent fruitful avenues of inquiry.

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